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Memorandum to: Sol Buchsbaum, Chairman
Defense Science Board

From: Walter Orr Roberts *WOR*

Subject: Key Issues of Interest to DoD in Weather
and Climate Change

Introductory

The impact of changes of weather and climate is huge. Nearly every aspect of human life is affected. I am concerned that I have not seen more attention by DSB to the advancing front of knowledge of prediction and control of weather and climate, nor to the military consequences of probable future climate scenarios. This memo, thus, highlights a few of the key issues that I envision to be of great present and potential DoD significance.

As I mentioned at the meeting on 28 February, I will prepare a 30-minute briefing on this for a future DSB meeting, if you wish and we have time on the agenda. I cannot be at the Summer Study, alas.

The State of Knowledge

Historical records document, to varying degrees of certainty, the following salient points:

- (1) Climate fluctuates with large amplitudes, in terms of human response, and over all time scales.
(Climate is usually defined as the time-average of weather elements over any specified period.)
- (2) Abrupt changes have historical precedent. (For example, around 550 BC the N. Europe winter worsened, leading in about 3 years to a shortening of the growing season by 20-30 days; the change persisted for centuries.)
- (3) From about 1890 to 1940 North Hemisphere (and probably world) temperatures rose significantly ($\sim 0.7^{\circ}\text{C}$), especially at high latitudes, leading to increasingly favorable world agriculture just as world populations zoomed upwards.

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- (4) A cooling has now set in, with adverse agricultural consequences in spite of today's greatly improved agronomic practices. (In the USSR growing seasons are now two weeks shorter than in 1940-50, and droughts more frequent.) The 1972 and 1974 crop failures, as well as the drastically lower world cereal reserves, and the rocketing food prices reflect this change and thus is all made worse by the rising food purchasing power of the wealthy nations and the upwards spiral of world populations.
- (5) For over 150 years there have been 20-22 year recurrent droughts in the high plains area of U.S. just east of the Rockies. There is some evidence that this is related to solar activity. If so, this has far-reaching consequences for theory, for practical forecasting and for possible human intervention.

Experts differ, with sometimes unbecoming passion, on the explanations. Arguments rage over whether the present and undisputed temperature downturn is a chance fluctuation likely as not to reverse next year, or a trend likely to persist for 25-50 years.

The competing theories for climatic change encompass the following, and more:

- (1) Volcanic activity adds a dust veil in the stratosphere, reducing incident solar energy at the earth's surface.
- (2) CO₂ enrichment of the atmosphere, resulting from human use of fossil fuels, is increasing the blanketing of outgoing IR while not reducing incoming sunlight (often incorrectly called the "greenhouse effect").
- (3) Ocean temperatures, driven by winds and other factors, influence air temperatures, radiative balance, and the large scale atmospheric flow.
- (4) Solar activity (especially the solar wind and the cosmic ray modulation) affect physical processes of the stratosphere and below, perhaps upsetting the atmospheric radiative balance of the earth, and through this, influencing stratospheric and tropospheric circulation.
- (5) Man-made small-particle dust and waste heat released to air and water are affecting the radiative system.

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- (6) Polar cooling, now in progress, results in the greater frequency of extremes of drought, flooding and other anomalies, and in dislocations of the large scale circulation that have particularly serious implications for the semi-arid and other-wise marginal lands into which husbandry and settlement are increasingly migrating.
- (7) Unpredictable "self-fluctuations" perturb climate.
- (8) Etc., etc.

Probably no single cause can explain all climatic changes. But no theory has a solid theoretical or experimental basis so far.

Key Issues

The key issues for DSB (and the Nation) to take a look at, in my view, are the following:

- (1) Severe food shortages are almost inevitable in the decadal time frame on all hypothesis of climate and weather change. These are bound to be politically unsettling. (Ethiopia and India and Bangladesh are --- examples. Future disasters could be catastrophically severe, and it is possible that 100 million could starve). Some analysts believe Khrushchev fell from power in part because of the failure of his dry-land farming policies (including support of Lysenko, whose effect on agriculture was a serious setback). Soil erosion, forest fire damage and other effects of droughts can influence the economy of a region for 15-25 years, as witness the "Dust Bowl" and the Sahel region, to say nothing of the long-term intellectual impact on mal-nourished children of even two years of deprivation.
- (2) The US and Canada are slated for further increased roles as the world's food suppliers, with all the favorable and unfavorable social, political, economic and ethical implications that this inevitably will bring. (We'll be increasingly blamed if people starve, I suspect, even though without our food there would be still less.)

- (3) The USSR has no way to be independent agriculturally, in the long term, if their food consumption habits continue to rise; the USSR is also far more vulnerable to climate change than we. The evidence is impressive that such a change is taking place for the worse right now. The USSR will be a food importer from US in nearly every imaginable scenario of the coming 25 years.
- (4) This country has no visible contingency plans for not-so-improbable global food disaster. We appear not to have explicit long-term policies to build food reserves, stabilize food prices, or to provide farm price supports to assure farmer incentive for high food production in US.
- (5) Research on climate change is not being forcefully advanced. Lip service is widespread, but unless or until our theoretical and observational work gets much stronger support, we are going to make slow progress in:
 - a. Theory of climatic change;
 - b. Testing of alternatives through laboratory experiments;
 - c. Expanding the observational data base for testing theories;
 - d. Provision of computer time for climate model experiments which make large computer capacity demands but are essential for progress;
 - e. Building manpower--competence in this domain is thin.
- (6) There is no major push that I know of to exploit the potentialities of the new genetic manipulation schemes (ie insertion of the precise amino acid in genetic structure to produce enhanced protein yield in a true-breeding corn) that are suggested by the recent spectaculars of genetic research.

Some Speculative Considerations

The question is often raised whether human activity through pollution, heat dumping, freon release, SST operation, smog generation,

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etc. is modifying climate and weather. Work is proceeding systematically, if slowly on these important issues.

However, a good deal of evidence exists suggesting that the weather-climate system is, at times at least, only conditionally stable to small perturbations. There is some evidence that very small energy releases, critically timed and geographically located, could trigger large and possibly long-lasting changes. There are speculative areas associated with stability considerations that need quantitative exploration suggesting awesome consequences of deliberate or inadvertent interventions.

Geophysical warfare, at climate time scales at least, presumably was banned, so far as US and USSR are concerned, by last July's somewhat ambiguous Nixon-Brezhnev "Joint Statement on Environmental Warfare." It appears, to me at least, that these bans were made in absence of any sophisticated or detailed discussion of what sorts of possible trigger-mechanisms may be inherent in the natural system. And this is understandable. But, I believe, that these trigger possibilities must have far more careful long-term study. We do not know where the triggers are, how sensitive they are, who can gain access to them, or even towards whom the gun is pointed.

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